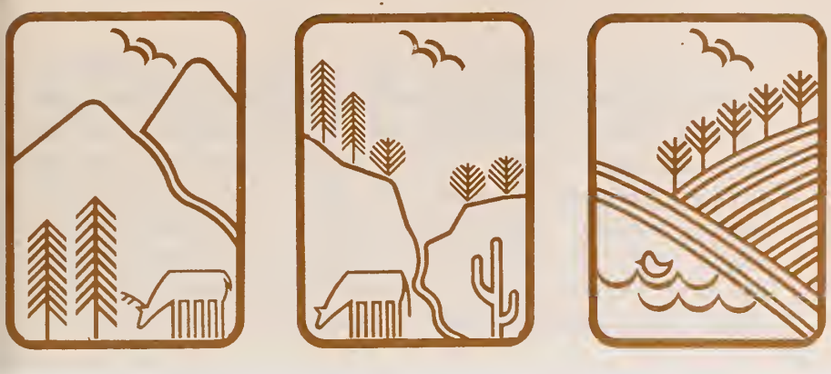
Rocky Mountains | Southwest | Great Plains



Research Note RM-388

August 1980

USDA Forest Service
Rocky Mountain Forest and Range Experiment Station

Development of Classes for Evaluating the Condition of Agricultural Conservation Program Conifer Plantings

William B. Kurtz, Thomas J. Mills, and Ralph J. Alig[1]

Five classes were developed to categorize 10- to 15-year-old conifer stands by silvicultural condition. Sample stands whose planting was cost-shared under the Agricultural Conservation Program were selected from broad regions of the eastern one-half of the United States. Screening criteria were age, site index, conifer and hardwood basal area, and density.

Keywords: stand condition, Agricultural Conservation Program, stand management, plantation

Categorization of timber stands by silvicultural condition was an important aspect of a study of the retention rate and current condition of Agricultural Conservation Program (ACP) conifer plantings 10-15 years old (Kurtz et al. 1980). Development of stand condition categories (classes) was a unique part of the study made necessary by the general absence of established silvicultural and economic criteria for use in evaluating the management direction for these stands.

Sample stands were screened and divided into five condition classes, reflecting whether previous followup treatment had occurred and whether any future followup treatment was needed to enable a stand to attain its productive potential. The evaluation was used to determine whether plantings should be retained for timber growing, should be treated in the near future, or will not need treatment.

[1]*The authors are Associate Professor, University of Missouri, Columbia; Project Leader, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Riverside, Calif.; and Forester, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo., respectively.*

Past Studies

Few studies have been conducted relating current stand condition to past management practices.

Dingle and Fletcher (1955) examined 1,419 farm tree plantings established between 1937 and 1948 from seedlings supplied by the Missouri Conservation Commission. They noted a positive relationship between planting survival and condition of planting stock, site condition prior to planting, suitability of planting method, and degree of plantation care. Only 11% of the plantings studied were judged to have received "good" care, while 47% had received "poor" care. Poor care included failure to provide protection from grazing, fire, and brush invasion. Survival ranged from 59% under good care to 35% under poor care.

The Tennessee Valley Authority (TVA), Division of Forestry Development (1962) surveyed 1,373 plantations established between 1934 and 1960 in the Tennessee Valley. Ten percent of these plantings had received ACP payments. Eighty-one percent of the plantations were still in existence. Eighty-five percent of the existing plantings were classified as having enough trees for successful timber production. Stocking was termed fair to good on over three-fourths of the existing plantings. While 17% were labeled as overstocked, only 4% were described as having poor stocking. Higher plantation success ratios (i.e., areas still in trees compared with areas planted) were associated with plantations that were never sold, were contract planted, and were planted on open land.

The extent, composition, and general condition of northern conifer plantations in the Northeast were examined by Kingsley and Mayer (1972). Nearly all of the poletimber and 76% of the sawtimber stands were greatly overstocked. Furthermore, many plantations suffered from hardwood invasion or needed pruning. Few cultural treatments had been applied after planting, particularly for private nonindustrial ownerships.

Williston and Dell (1974) found that, in Civilian Conservation Corps (CCC) pine plantations in northern Mississippi, only 8,005 (35%) of 22,575 acres planted to pine between 1934 and 1942 were still in plantations. Approximately 19% of the area had been invaded by hardwood species. Over the 10-year study period from 1959 to 1969, one-third of the area was clearcut prematurely. Most of that land was converted to pasture. Furthermore, roughly one-fourth of the area was understocked, with basal areas too low to adequately protect or fully utilize the sites.

Williston (1972) examined 3,875 pine plantations encompassing 66,095 acres on the Yazoo-Little Tallahatchie (Y-LT) Flood Prevention Project in north Mississippi. Fifteen percent of the total acreage had been taken out of plantations. Of those acres, 43% had been clearcut for posts or pulpwood, 28% cleared for pasture, 12% destroyed by fire, and 7% invaded by hardwoods.

Alig et al. (1980) found that, of the pine plantations initiated in the South under the Soil Bank Program from 1956 to 1960, 86% supported measurable volumes of growing stock. Many of the retained plantations were overstocked and in need of thinning, but only 5% were in poor condition. The average volume of growing stock measured on retained plantation acreage was over 22 cords per acre. An average of 6 cords per acre had been harvested from the original plantation acreage.

These studies indicate that followup treatments are not applied as frequently as needed on nonindustrial private lands. Since study methods varied and each study addressed a somewhat restricted geographic area, it is difficult to ascertain any consistent relationships between stand condition and past management practices.

Data Collection

Sampling Procedure

Sample states were selected from within broad regions of the eastern one-half of the United States based upon their representativeness and willingness to assist in the study. The sample states by region were Missouri (Central Region), Wisconsin (North Central Region), Pennsylvania (Northeast Region), South Carolina (Southeast Region), and Mississippi (South Central Region). Selecting individual states within these regions, rather than drawing samples from the entire region, greatly reduced travel time and the time spent contacting state forestry personnel. To maintain consistency, one person prepared measurements on all sample cases. Sampling in five states permitted this more easily than sampling regionwide.

Since these five states were willing to cooperate in the study and had records of plantings 10-15 years old, the quality of their state forestry agencies may be above average. If so, there may be a bias in the results toward higher retention and better condition than exists on the average. Furthermore, there may have been some bias in selection of the areas studied. For example, the average tract size within the counties sampled was generally greater than the statewide average tract size of ACP tree planting practices.[2]

A target sample of 50 cases, 10 acres or larger, per state was set. Within each state, 8-15 service forester areas were selected for sampling based on having large ACP workloads and retention of sufficient records. Three to twelve sample cases were then randomly selected in each service forester area. The number selected was in proportion to the number of ACP cases serviced by year for the service forester area. The sample age bracket had to be expanded from 10-15 years to 8-17 years of age to obtain a sufficient number of observations containing at least 10 planted acres.

[2]*Ensminger, R. K. 1977. Personal correspondence. USDA Agricultural Stabilization and Conservation Service, Washington, D.C. (on file at School of Forestry, Fisheries and Wildlife, University of Missouri, Columbia.)*

Field evaluation of the selected case tracts by one of the authors (Alig) took place during the fall of 1976 and summer of 1977. A total of 312 tracts were examined, containing an original planted acreage of 6,320 acres.

Condition Data

The following data were gathered for each sample tract:

1. Current condition of conifer component: percent basal area in dominant and codominant crown position; and species data on density, basal area, and average diameter at breast height (d.b.h.).

2. Current condition of hardwood component: percent basal area in dominant and codominant crown position; evidence of suppression attempt; apparent age; and species data on density, basal area, and average d.b.h.

3. Current condition of understory component: density and total density by height class.

4. Subsequent timber activity: replanting (age, acres, species); precommercial thin (age, acres); hardwood control (age, acres, percent basal area removed); and timber harvest (age, acres, percent basal area removed).

Condition Class Development

Five condition classes were developed to screen the sample cases into management groups. Screening criteria were age, site index, conifer and hardwood basal area, and density.

Condition classes were developed for each of the following species groups found to be dominant on various sites: shortleaf pine (*Pinus echinata* Mill.); loblolly pine (*Pinus taeda* L.) and slash pine (*Pinus elliottii* Engelm.); eastern white pine (*Pinus strobus* L.), red pine (*Pinus resinosa* Ait.), and jack pine (*Pinus banksiana* Lamb.); Norway spruce (*Picea abies* (L.) Karst.) and white spruce (*Picea glauca* (Moench. Voss.); European larch (*Larix decidua* Mill.) and Japanese larch (*Larix leptolepis* (Sieb. and Zucc.) Gord.); and Austrian pine (*Pinus nigra* Arnold). Criteria for the condition classes for these dominant species appear in table 1.

The various classes were developed from a search of pertinent literature as well as from a survey of individuals knowledgeable about management of the respective species groups. Because of the relative lack of yield information for intermediate treatments of certain conifer types, these expert opinions were particularly important. It must be remembered that these condition classes are based upon silvicultural guidelines which generally have not been subjected to verification by financial analysis. The exception to this is an investment analysis of the Mississippi samples drawn for this study.[3] That analysis indicated management of the Mississippi samples in nonretainable condition classes would produce negative present net worths at discount rates higher than 10% even if land costs were not included in the investment framework. A description of the stand condition classes follows:

Class 1: Do not retain.—This class contains stands which should not be retained for timber production because of an unacceptable low level of conifer stocking. Maximum conifer basal area and maximum conifer density limits were established by stand age group and site index range. Two maximum conifer densities were developed based on the average d.b.h. of conifer trees on the site.

Class 2: Do not retain.—Stands which contain an overabundance of hardwood stocking in relation to conifer stocking are placed in this class. In general, when hardwood stocking exceeded 50-55% of total basal area of the stand, the most sensible option was to not retain the remaining conifer component for timber production. In some cases, this relative excess of hardwoods was due to hardwood invasion after an initial low conifer stocking or after damage to the conifer component by fire, disease, or insects.

Class 3: Retain.—Stands in this class should be retained from a silvicultural standpoint, but will require a reduction in conifer stocking within 3-5 years in order to allow the stand to approximate its maximum possible yield. Minimum conifer basal area and minimum conifer density thresholds were established for each stand age group and site index.

Class 4: Retain.—Stands in this class should be retained, but will require hardwood removal within 3-5 years. If this treatment is not applied, a reduction in final conifer yield will occur. In general, this hardwood treatment is needed if hardwood stocking was from one-third to one-half of total basal area. An additional upper limit of from 160-200 free-growing conifer trees per acre, depending on principal conifer species, was established in order to more completely define this class.

Class 5: Retain.—Stands in this class need no silvicultural treatment for at least 3-5 years. Acceptable ranges for conifer basal area and conifer density were developed based on the upper and lower limits established for classes 1 and 3, respectively. Maximum acceptable hardwood stocking established in class 4 is an additional criterion which must be met.

[3] *Alig, Ralph J., William B. Kurtz, and Thomas J. Mills. 1980. The financial return of intermediate treatments in 8- to 15-year-old southern pine plantations varies with stand condition. Southern Journal of Applied Forestry. (manuscript in process).*

Table 1.—Description of condition classes

Species age	Site index	Class 1—Do not retain because of low conifer stocking[1]		Class 2—Do not retain because of high hardwood stocking	Class 3—Retain but treatment is required within 3-5 years because of high conifer stocking[2]		Class 4—Retain but treatment is required within 3-5 years because of high hardwood stocking	Class 5—Retain and no treatment is required for at least 3-5 years[1]	
		Maximum conifer basal area	Maximum conifer density	Maximum conifer basal area	Minimum conifer basal area	Maximum conifer density	Conifer basal area[3]	Conifer basal area	Maximum conifer density[4]
years	*height at 50 years*	*square feet per acre*	*trees per acre—diameter in inches*	*percent of total stand*	*square feet per acre*	*trees per acre*	*percent of total stand*	*square feet per acre*	*trees per acre*
Shortleaf pine[5]									
8-10	<50	30	150-3.5 or 250-2	50	95	1,300	50-67	30-95	1,300
	50-65	35	175-3.5 or 275-2	50	100	1,400	50-67	35-100	1,400
	66+	40	200-3.5 or 300-2	50	105	1,500	50-67	40-105	1,500
11-13	<50	40	130-4 or 230-2.5	50	105	1,200	50-67	40-105	1,200
	50-65	45	150-4 or 250-2.5	50	110	1,300	50-67	45-110	1,300
	66+	50	170-4 or 270-2.5	50	115	1,400	50-67	50-115	1,400
14-16	<50	50	110-5 or 210-3	50	115	1,100	50-67	50-115	1,100
	50-65	55	130-5 or 230-3	50	120	1,200	50-67	55-120	1,200
	66+	60	150-5 or 250-3	50	125	1,300	50-67	60-125	1,300
Loblolly and slash pine[6]									
8-10	<80	30	120-4 or 220-2.4	50	95	1,300	50-67	30-95	1,300
	80-100	35	150-4 or 250-2.5	50	100	1,400	50-67	35-100	1,400
	101+	40	180-4 or 280-2.6	50	108	1,500	50-67	40-108	1,500
11-13	<80	40	90-5 or 190-2.6	50	102	1,200	50-67	40-102	1,200
	80-100	45	100-5 or 200-2.7	50	110	1,300	50-67	45-110	1,300
	101+	50	110-5 or 210-2.8	50	118	1,400	50-67	50-118	1,400
14-16	<80	50	80-6 or 180-2.8	50	115	1,100	50-67	50-115	1,100
	80-100	55	90-6 or 190-2.9	50	120	1,200	50-67	55-120	1,200
	101+	60	100-6 or 200-3.0	50	128	1,300	50-67	60-128	1,300
White, red, and jack pine[7]									
8-10	<55	45	425-4 or 525-2.5	50	130	1,100	50-70	45-130	1,100
	55-75	50	450-4 or 550-2.5	50	135	1,200	50-70	50-135	1,200
	76+	55	475-4 or 575-2.5	50	140	1,300	50-70	55-140	1,300
11-13	<55	55	375-5 or 475-3	50	140	1,000	50-70	55-140	1,000
	55-75	60	400-5 or 500-3	50	145	1,100	50-70	60-145	1,100
	76+	65	425-5 or 550-3	50	150	1,200	50-70	65-150	1,200
14-16	<55	60	350-5.5 or 400-3	50	145	950	50-70	60-145	950
	55-75	65	375-5.5 or 450-3	50	150	1,050	50-70	65-150	1,050
	76+	70	400-5.5 or 500-3	50	155	1,150	50-70	70-155	1,150

8-10	<55	25	500-3 or 650-1.5	45	125	1,100	45-65	25-125	1,100
	55-75	30	550-3 or 700-1.5	45	130	1,200	45-65	30-130	1,200
	76+	35	600-3 or 750-1.5	45	135	1,300	45-65	35-135	1,300
11-13	<55	30	500-3 or 650-1.5	45	135	1,000	45-65	30-135	1,000
	55-75	35	550-3 or 700-1.5	45	140	1,100	45-65	35-140	1,100
	76+	40	600-3 or 750-1.5	45	145	1,200	45-65	40-145	1,200
14-16	<55	35	400-3.5 or 550-2	45	140	900	45-65	35-140	900
	55-75	40	450-3.5 or 600-2	45	145	1,000	45-65	40-145	1,000
	76+	45	500-3.5 or 650-2	45	150	1,100	45-65	45-150	1,100
European and Japanese larch[9]									
8-10	<55	35	275-4 or 375-2.5	50	105	1,100	50-70	35-105	1,100
	55-75	40	300-4 or 400-2.5	50	110	1,200	50-70	40-110	1,200
	76+	45	325-4 or 425-2.5	50	115	1,300	50-70	45-115	1,300
11-13	<55	45	225-4.5 or 325-3	50	115	1,000	50-70	45-115	1,000
	55-75	50	250-4.5 or 350-3	50	120	1,100	50-70	50-120	1,100
	76+	55	275-4.5 or 375-3	50	125	1,200	50-70	55-125	1,200
14-16	<55	55	200-5 or 300-3.5	50	125	900	50-70	55-125	900
	55-75	60	225-5 or 325-3.5	50	130	1,000	50-70	60-130	1,000
	76+	65	250-5 or 350-3.5	50	135	1,100	50-70	65-135	1,100
Austrian pine[10]									
8-10	<55	40	375-3.5 or 450-2	50	125	1,100	50-67	40-125	1,100
	55-75	45	400-3.5 or 475-2	50	130	1,200	50-67	45-130	1,200
	76+	50	425-3.5 or 500-2	50	135	1,300	50-67	50-135	1,300
11-13	+55	50	325-4 or 400-2.5	50	135	1,000	50-67	50-135	1,000
	55-75	55	350-4 or 425-2.5	50	140	1,100	50-67	55-140	1,100
	76+	60	375-4 or 450-2.5	50	145	1,200	50-67	60-145	1,200
14-16	<55	55	275-5 or 350-3	50	145	900	50-67	55-145	900
	55-75	60	300-5 or 375-3	50	150	1,000	50-67	60-150	1,000
	76+	65	325-5 or 400-3	50	155	1,100	50-67	65-155	1,100

[1]Planting characteristics must conform to both parameters in order to be placed in this class.

[2]Planting characteristics need only exceed one of the parameters in order to be placed in this class.

[3]Treatment would not be required if there are more than a certain number of free-growing conifer trees per acre. The threshold level is 175 for shortleaf pine; 160 for loblolly and slash pine; 200 for white, red, and jack pine; 225 for Norway and white spruce; 185 for European and Japanese larch; and 180 for Austrian pine.

[4]Minimum conifer density is threshold level specified for class 1.

[5]Sources: Personal communications—H. E. Garrett, School of Forestry, Fisheries and Wildlife, University of Missouri, Columbia; N. F. Rogers, private forestry consultant, Salem, Mo. Literature—Brinkman and Rogers, 1967, Brinkman and Smith 1968, U.S. Department of Agriculture, Forest Service 1971.

[6]Sources: Personal communications—W. C. Anderson, U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, New Orleans, La.; W. E. Balmer, U.S. Department of Agriculture, Forest Service, Southeast Area, State and Private Forestry, Atlanta, Ga.; M. Gaffney, South Carolina Commission of Forestry, Columbia; C. H. Morgan, Mississippi Forestry Commission, Jackson; R. Shackleford, U.S. Department of Agriculture, Forest Service, State and Private Forestry, Washington, D.C.; H. L. Williston, U.S. Department of Agriculture, Forest Service, Southeast Area State and Private Forestry, Jackson, Miss. Literature—Langdon and Trousdell 1974, Mann and Enghardt 1972, Mann and Lohrey 1974, U.S. Department of Agriculture, Forest Service 1971.

[7]Sources: Personal communications—J. W. Benzie, U.S. Department of Agriculture, Forest Service, Northern Conifers Laboratory, Grand Rapids, Minn.; W.S. Corlett, Pennsylvania Department of Environmental Resources, Harrisburg; A.L. Lundgren, U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, Minn.; W. W. Ward, School of Forest Resources, Pennsylvania State University, University Park. Literature—Bartoo et al. 1963, Benzie 1977a, Benzie 1977b, Philbrook et al. 1973, Schlaegel 1971.

[8]Source: Frank and Bjorkbom 1973.

[9]Source: Douglass, R. W. 1961. The place of Japanese larch Larix leptolepis *in Pennsylvania forestry. Unpublished M.S. thesis, Pennsylvania State University,* University Park.

[10]Source: Melton 1972

Note: Plantings may also be placed into nonretention classes because of fire, disease, insect, storm, or other damage that may be present in a planting along with low conifer stocking or high hardwood stocking.

Conditions of Stands

Tracts which should not be retained because of poor condition (condition classes 1 and 2) comprised 11% of the sample (table 2). An additional 43% were in retainable condition, but require some followup treatment within 3-5 years (condition classes 3 and 4). Conifer overstocking was the predominant reason followup treatments were required. This is consistent with the observations recorded by Kingsley and Mayer (1972), the Tennessee Valley Authority, Division of Forestry Development (1962), and Alig et al. (1980), all of which concluded that many of the stands examined were overstocked and in need of thinning. The remaining 41% of the sample cases require no treatment for at least 3-5 years (condition class 5). The range of cases in this class was from 31% in Missouri to 52% in South Carolina.

Site preparation had been applied to 62% of the cases in the do not retain classes. Since the need for site preparation is well documented, this would suggest that the amount or quality of site preparation in these cases was frequently inadequate, especially in controlling hardwood competition.

There was a close relationship between current stand condition and whether the original planting was an underplanting or not. Fifty-six percent of the underplantings were classified as being in nonretainable condition, which is over five times as large as the overall sample percentage (11%). There is considerable need for prompt release of underplantings from their overstory competition; the residual overstory was generally hardwood species. Unfortunately, not enough of the underplanted stands received this release. The conifer component in the average underplanting case was in noticeably poorer condition than it was in the average sample case. Even though there were usually sufficient conifer stems per acre (466), they had a smaller average d.b.h. (3.5 inches) than the all case conifer average of 4.4 inches and were competing with 195 hardwood trees that were 6.3 inches in d.b.h. A large percentage of the sampled understory plantings also had more hardwood basal area than conifer.

All harvests occurred in stands in the "retain" condition classes, and the majority occurred in stands that need no treatment within 3-5 years (condition class 5). It is logical that only well stocked stands were harvested, but the study results also show that the stands were not overcut so as to result in an insufficient residual conifer stocking.

Conclusions

Based on the condition classification, it was determined that a high percentage of the stands examined have the potential to attain desirable forest management goals. Eleven percent were in poor enough condition, because of

Table 2.—Percent of case tracts by condition class by state[1]

State	Class 1—Do not retain because of low conifer stocking	Class 2—Do not retain because of high hardwood stocking	Class 3—Retain but treatment is required within 3-5 years because of high conifer stocking	Class 4—Retain but treatment is required within 3-5 years because of high hardwood stocking	Class 5—Retain and no treatment is required for at least 3-5 years
	percent				
Missouri	0.0	17.3	42.3	7.7	30.8
Mississippi	0.0	7.8	42.2	9.4	34.4
South Carolina	1.6	4.7	28.1	9.4	51.6
Wisconsin	7.7	1.5	43.1	0.0	44.6
Pennsylvania	23.9	11.9	10.4	11.9	32.8
All sample states	5.4	5.4	36.9	6.0	41.3

[1]*Percent calculation is based on total number of cases for each state and all sample states.*

an overstocking of hardwoods or an understocking of conifers, that they should not be retained if the objective is timber production. An additional 43% of the retained cases should receive treatment within the next 3-5 years for them to approximate their maximum potential yield. The most widespread need (37%) is a thinning to reduce the conifer density, but 6% also need hardwood control. If these tracts are not treated, they may eventually slip into the nonretainable condition classes.

The overall lack of stand treatments after planting (e.g., hardwood removal) has led to over two-fifths of the tracts needing immediate treatments. Even though some underplantings were placed in a "treat but retainable" condition class, the cost of removing the large amount of hardwood basal area may lead to relatively low financial returns.

Literature Cited

Alig, Ralph J., Thomas J. Mills, and Robert L. Shackleford. 1980. Most Soil Bank plantings in the South have been retained; some need follow-up treatments. Southern Journal of Applied Forestry 4(1):60-64.

Bartoo, R. A., W. W. Ward, and Rex E. Melton. 1963. Early thinnings in a red pine plantation. Pennsylvania State University Forestry School Research Paper 33, 12 p. University Park.

Benzie, John W. 1977a. Manager's handbook for jack pine in the north central states. USDA Forest Service General Technical Report NC-32, 18 p. North Central Forest Experiment Station, St. Paul, Minn.

Benzie, John W. 1977b. Manager's handbook for red pine in the north central states. USDA Forest Service General Technical Report NC-33, 22 p. North Central Forest Experiment Station, St. Paul, Minn.

Brinkman, Kenneth A., and Nelson F. Rogers. 1967. Timber management guide for shortleaf pine and oak-pine types in Missouri. USDA Forest Service Research Paper NC-19, 15 p. North Central Forest Experiment Station, St. Paul, Minn.

Brinkman, Kenneth A., and Richard C. Smith. 1968. Managing shortleaf pine in Missouri. Missouri Agricultural Experiment Station Bulletin 875, 35 p. University of Missouri, Columbia.

Dingle, Richard W., and Peter W. Fletcher. 1955. A survey of forest tree plantings in Missouri. Missouri Agricultural Experiment Station Bulletin 640, 20 p. University of Missouri, Columbia.

Frank, Robert M., and John C. Bjorkbom. 1973. A silvicultural guide for spruce-fir in the Northeast. USDA Forest Service General Technical Report NE-6, 29 p. Northeastern Forest Experiment Station, Upper Darby, Pa.

Kingsley, Neal P., and Carl E. Mayer. 1972. The extent, composition, and general condition of northern conifer plantations in the northern region. 25 p. USDA Forest Service, Northeastern Forest Experiment Station, Upper Darby, Pa. [presented at Conference on utilization of plantation grown northern softwoods, State University of New York, College of Environmental Science and Forestry, Syracuse University, Syracuse, September 6-7, 1969].

Kurtz, William B., Ralph J. Alig, and Thomas J. Mills. 1980. Retention and condition of Agricultural Conservation Program conifer plantings. Journal of Forestry 78(5): 273-276.

Langdon, O. Gordon, and Kenneth B. Trousdell. 1974. Increasing growth and yield of natural loblolly pine by young stand management. *In* Proceedings of the symposium on management of young pines. [Charleston, S.C., December 3-5, 1974] U.S. Department of Agriculture, Southeastern Area, State and Private Forestry, Atlanta, Ga. 349 p.

Mann, William F., Jr., and Hans G. Enghardt. 1972. Growth of planted slash pine under several thinning regimes. USDA Forest Service Research Paper S0-76, 10 p. Southern Forest Experiment Station, New Orleans, La.

Mann, William F., Jr., and Richard E. Lohrey. 1974. Precommercial thinning of southern pines. Journal of Forestry 72(9):557-560.

Melton, Rex E. 1972. Austrian pine plantation performance on the Stone Valley Experimental Forest. Pennsylvania Agricultural Experiment Station Progress Report 328, 10 p. Pennsylvania State University, University Park.

Philbrook, James S., James P. Barrett, and William B. Leak. 1973. A stocking guide for eastern white pine. USDA Forest Service Research Note NE-168, 3 p. Northeastern Forest Experiment Station, Upper Darby, Pa.

Schlaegal, Bryce E. 1971. White pine production best at high stocking. USDA Forest Service Research Note NC-115, 2 p. North Central Forest Experiment Station, St. Paul, Minn.

Tennessee Valley Authority, Division of Forestry Development. 1962. A report of 85,700 forest plantations in the Tennessee Valley. 8 p. Norris, Tenn.

U.S. Department of Agriculture, Forest Service. 1971. Thinning pine plantations in 1971 and after. Forest Management Bulletin, 6 p. Southeastern Area State and Private Forestry, Atlanta, Ga.

Williston, Hamlin L. 1972. The question of adequate stocking. Tree Planters' Notes 23(1):9-10.

Williston, Hamlin L., and Tommy R. Dell. 1974. Growth of pine plantations in north Mississippi. USDA Forest Service Research Paper S0-94, 15 p. Southern Forest Experiment Station, New Orleans, La.

Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico
Bottineau, North Dakota
Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
Lubbock, Texas
Rapid City, South Dakota
Tempe, Arizona

*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526